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Cerro Gordo County, Iowa

Corvallis Environmental Research Lab, Oreg

Prepared for

Environmental Monitoring and Support Lab, Las Vegas, Nev

Aug 76

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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NATIONAL EUTROPHICATION SURVEY

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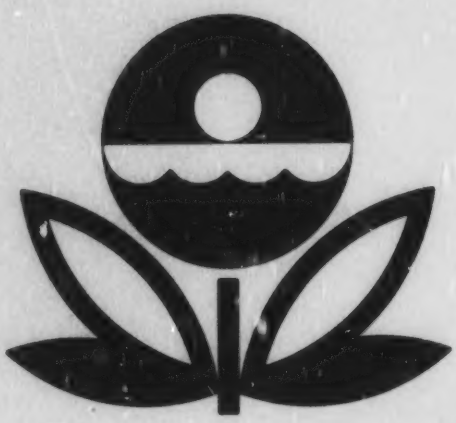

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

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Report
on
Clear Lake
Cerro Gordo County
Iowa
EPA Region VII
Working Paper No. 497

With the cooperation of the
Iowa Department of Environmental Quality
and the
Iowa National Guard
August, 1976

CONTENTS

	Page
Foreword	ii
List of Iowa Study Lakes	iv
Lake and Drainage Area Map	v
Sections	
I. Introduction	1
II. Conclusions	1
III. Lake and Drainage Basin Characteristics	3
IV. Lake Water Quality Summary	4
V. Literature Reviewed	8
VI. Appendices	9

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Iowa Department of Environmental Quality for professional involvement, to the Iowa National Guard for conducting the tributary sampling phase of the Survey, and to those wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Water Quality Division of the Department of Environmental Quality provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

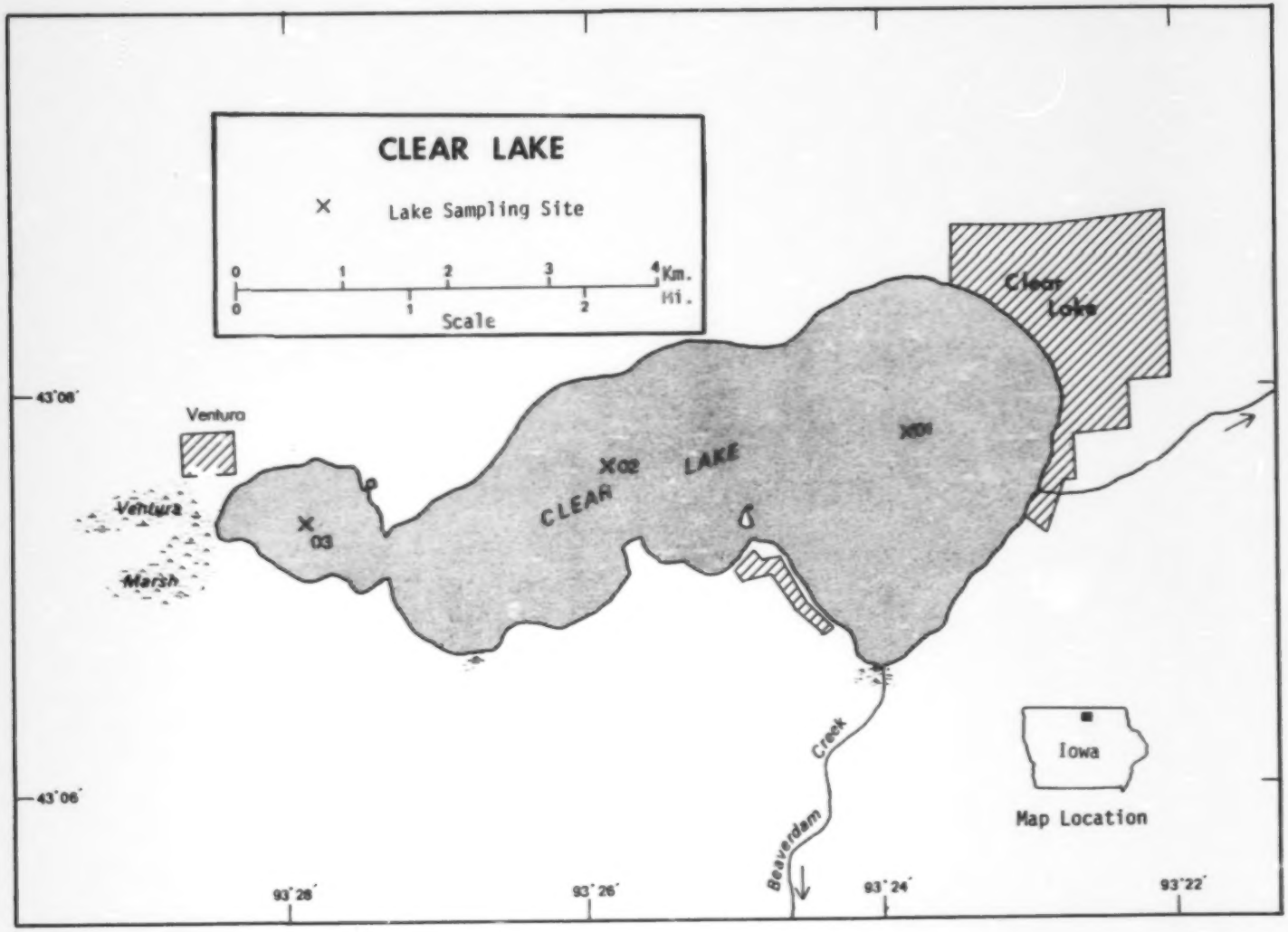
Major General Joseph G. May, the Adjutant General of Iowa, and Project Officer Colonel Cleadeth P. Woods, who directed the volunteer efforts of the Iowa National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF IOWA

LAKE NAME	COUNTY
Ahquabi	Warren
Big Creek Reservoir	Polk
Black Hawk	Sac
Clear	Cerro Gordo
Darling	Washington
Lost Island	Clay, Palo Alto
MacBride	Johnson
Prairie Rose	Shelby
Rathbun Reservoir	Appanoose, Wayne
Red Rock Reservoir	Marion
Rock Creek	Jasper
Silver	Worth
Spirit	Dickinson
Viking	Montgomery
West Okoboji	Dickinson


CLEAR LAKE
Lake Sampling Site
0 1 2 3 4 Km.
0 1 2 Mi.
Scale
Clear Lake
43°08'
Ventura
Ventura Marsh
X01
X02
X03
CLEAR LAKE
Beaverdam Creek
Iowa
Map Location
43°06'
93°28'
93°26'
93°24'
93°22'

CLEAR LAKE

STORET NO. 1904

I. INTRODUCTION

Clear Lake was included in the National Eutrophication Survey as a water body of interest to the Iowa Department of Environmental Quality. Tributaries and nutrient sources were not sampled, and this report relates only to the lake sampling data.

Clear Lake is a natural, eutrophic lake located in Cerro Gordo County in north central Iowa. The watershed consists mainly of woods and agricultural lands. There are no surface streams supplying water to the lake (Percy, 1953).

The lake is heavily used for recreation. The Iowa Conservation Commission estimates that 500,000 persons visit the parks and beaches around the lake each year. Over 70% of the shoreline of the lake is occuppied by private homes, cabins, and commercial establishments.

Walleyes, crappies, and white bass are the major game fish species found in Clear Lake, but perch, northern pike, and muskellunge can also be caught (Mayhew, 1975).

II. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Clear Lake is eutrophic. Of the 15 Iowa lakes and reservoirs sampled in 1974, Clear Lake ranked fourth in overall trophic quality when compared using

a combination of six water quality parameters*. Four of the water bodies had less median total phosphorus, four had less and two had the same median orthophosphorus, two had less median inorganic nitrogen, nine had less mean chlorophyll a, and six had greater mean Secchi disc transparency.

Survey limnologists did not observe any concentrations of algae but did note the occurrence of emergent weeds along the north and east shorelines.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Clear Lake was phosphorus limited at the time the assay sample was collected (04/18/74). The lake data indicate phosphorus limitation in April but nitrogen limitation in September.

* See Appendix A.

III. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 14.74 kilometers^2.
2. Mean depth: 3.0 meters.
3. Maximum depth: 5.7 meters.
4. Volume: 44.220 x 10^6 m^3.
5. Mean hydraulic retention time: unknown.

C. Precipitation*:

1. Year of sampling: 75.2 centimeters.
2. Mean annual: 74.7 centimeters.

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† Table of metric conversions--Appendix B.
†† Harrison, 1975.
* See Working Paper No. 175, "...Survey Methods, 1973-1976".

IV. LAKE WATER QUALITY SUMMARY

Clear Lake was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from one or more depths at three stations on the lake (see map, page v). During each visit, a single depth-integrated (near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was composited from each of the stations for chlorophyll a analysis. The maximum depths sampled were 3.0 meters at stations 1 and 2 and near-surface at station 3.

The sampling results are presented in full in Appendix C and are summarized in the following table (the July nutrient samples were not preserved properly and were not analyzed).

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR CLEAR LAKE
STONET CODE 1904

	1ST SAMPLING (4/18/74) 3 SITES			2ND SAMPLING (7/ 3/74) 3 SITES			3RD SAMPLING (9/23/74) 3 SITES		
PARAMETER	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	8.8 - 11.4	9.4	9.0	23.5 - 24.2	23.7	23.6	13.5 - 14.9	14.6	14.6
DISS OXY (MG/L)	10.4 - 11.8	11.2	11.4	6.4 - 8.2	7.1	7.1	9.0 - 9.8	9.3	9.2
CNDCTVY (MCROMO)	24. - 184.	87.	81.	394. - 400.	397.	397.	251. - 286.	271.	272.
PH (STAND UNITS)	8.3 - 8.7	8.4	8.3	8.6 - 8.7	8.6	8.6	8.3 - 8.5	8.4	8.4
TOT ALK (MG/L)	140. - 148.	146.	147.	****** -**********			155. - 168.	163.	164.
TOT P (MG/L)	0.024 - 0.057	0.036	0.030	****** -**********			0.059 - 0.097	0.078	0.078
ORTHO P (MG/L)	0.006 - 0.031	0.014	0.010	****** -**********			0.007 - 0.011	0.010	0.010
NO2+NO3 (MG/L)	0.240 - 1.000	0.390	0.275	****** -**********			0.020 - 0.030	0.023	0.020
AMMONIA (MG/L)	0.080 - 0.200	0.173	0.190	****** -**********			0.040 - 0.050	0.041	0.040
KJEL N (MG/L)	1.100 - 1.300	1.217	1.200	****** -**********			1.000 - 1.500	1.186	1.100
INORG N (MG/L)	0.430 - 1.080	0.563	0.465	****** -**********			0.060 - 0.070	0.064	0.060
TOTAL N (MG/L)	1.390 - 2.200	1.607	1.525	****** -**********			1.020 - 1.520	1.209	1.130
CHLRPYL A (UG/L)	12.4 - 29.4	18.1	12.6	6.1 - 31.1	15.8	10.3	15.1 - 22.1	18.2	17.5
SECCHI (METERS)	1.4 - 1.4	1.4	1.4	0.5 - 0.9	0.7	0.8	0.4 - 0.9	0.7	0.9

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/18/74	1. Dinobryon sp.	5,340
	2. Melosira sp.	3,432
	3. Fragilaria sp.	2,091
	4. Asterionella sp.	884
	5. Flagellates	793
	Other genera	2,649
	Total	15,189
07/03/74	1. Melosira sp.	5,919
	2. Microcystis sp.	3,277
	3. Coelosphaerium sp.	1,609
	4. Oocystis sp.	536
	5. Fragilaria sp.	536
	Other genera	2,242
	Total	14,119
09/23/74	1. Microcystis sp.	8,662
	2. Aphanocapsa sp.	3,948
	3. Flagellaria sp.	471
	4. Blue-green filaments	236
	5. Cryptomonas sp.	236
	Other genera	2,416
	Total	15,969

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
04/18/74	1	12.6
	2	12.4
	3	29.4
07/03/74	1	6.1
	2	10.3
	3	31.1
09/23/74	1	15.1
	2	17.5
	3	22.1

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.010	0.485	2.8
0.050 P	0.060	0.485	18.4
0.050 P + 1.0 N	0.060	1.485	31.9
1.0 N	0.010	1.485	3.9

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Clear Lake was moderately high at the time the sample was taken (04/18/74). Also, a six-fold increase in yield with the addition of only orthophosphorus indicates that the lake was limited by phosphorus at that time. Note that the addition of only nitrogen produced a yield not significantly greater than the control yield.

The lake data also indicate phosphorus limitation in April; i.e., the mean inorganic nitrogen to orthophosphorus ratios were 24 to 1 or greater at all stations. However, the September lake data indicate that the lake was nitrogen limited; i.e., the mean N/P ratios were 8 to 1 or less at all stations, and nitrogen limitation would be expected.

V. LITERATURE REVIEWED

Harrison, Harry M., 1975. Personal communication (lake morphometry). IA Cons. Comm., Des Moines.

Mayhew, James, 1975. Personal communication (lake uses and development). IA Cons. Comm., Des Moines.

Percy, William G., 1953. "Some limnological features of Clear Lake, Iowa". IA St. Coll. Jour. Sci. 28(2):189-207.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1901	LAKE ACQUABI	0.062	0.335	469.333	8.600	8.200	0.009
1902	BIG CREEK RESERVOIR	0.046	6.465	438.500	16.867	14.800	0.011
1903	BLACK HAWK LAKE	0.185	0.130	488.167	49.740	15.000	0.020
1904	CLEAR LAKE	0.059	0.070	465.125	17.400	8.600	0.010
1905	LAKE DARLING	0.077	1.475	482.500	13.817	9.200	0.012
1906	LOST ISLAND LAKE	0.146	0.065	421.167	36.100	8.400	0.021
1907	LAKE MACBRIDE	0.061	2.035	458.444	17.067	15.000	0.010
1908	PRAIRIE ROSE LAKE	0.056	0.210	463.667	17.350	8.600	0.010
1909	RATHBUN RESERVOIR	0.071	1.170	475.889	12.039	14.000	0.008
1910	RED ROCK LAKE	0.180	1.880	473.400	14.730	14.000	0.104
1911	ROCK CREEK LAKE	0.065	1.400	480.500	18.367	8.400	0.007
1912	SILVER LAKE	0.193	0.565	482.667	95.300	10.000	0.034
1913	SPIRIT LAKE	0.041	0.090	422.667	12.622	9.000	0.007
1914	VIKING LAKE	0.075	0.130	459.000	26.033	14.200	0.017
1915	WEST LAKE OKOBOJI	0.046	0.060	380.444	7.722	15.000	0.017

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NU
1901	LAKE ACQUABI	57 (8)	50 (7)	43 (6)	93 (13)	100 (14)	79 (11)	422
1902	BIG CREEK RESERVOIR	89 (12)	0 (0)	79 (11)	57 (8)	21 (3)	50 (7)	296
1903	BLACK HAWK LAKE	7 (1)	68 (9)	0 (0)	7 (1)	7 (0)	21 (3)	110
1904	CLEAR LAKE	71 (10)	86 (12)	50 (7)	36 (5)	75 (10)	64 (8)	382
1905	LAKE DARLING	29 (4)	21 (3)	14 (2)	71 (10)	57 (8)	43 (6)	235
1906	LOST ISLAND LAKE	21 (3)	93 (13)	93 (13)	14 (2)	89 (12)	14 (2)	324
1907	LAKE MACBRIDE	64 (9)	7 (1)	71 (10)	50 (7)	7 (0)	64 (8)	263
1908	PRAIRIE ROSE LAKE	79 (11)	57 (8)	57 (8)	43 (6)	75 (10)	64 (8)	375
1909	RATHBUN RESERVOIR	43 (6)	36 (5)	29 (4)	86 (12)	39 (5)	86 (12)	319
1910	RED ROCK LAKE	14 (2)	14 (2)	36 (5)	64 (9)	39 (5)	0 (0)	167
1911	ROCK CREEK LAKE	50 (7)	29 (4)	21 (3)	29 (4)	89 (12)	96 (13)	314
1912	SILVER LAKE	0 (0)	43 (6)	7 (1)	0 (0)	50 (7)	7 (1)	107
1913	SPIRIT LAKE	100 (14)	79 (11)	86 (12)	79 (11)	64 (9)	96 (13)	504
1914	VIKING LAKE	36 (5)	68 (9)	64 (9)	21 (3)	29 (4)	32 (4)	250
1915	WEST LAKE OKOBOJI	89 (12)	100 (14)	100 (14)	100 (14)	7 (0)	32 (4)	428

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1913	SPIRIT LAKE	504
2	1915	WEST LAKE OKOBOJI	428
3	1901	LAKE ACQUABI	422
4	1904	CLEAR LAKE	382
5	1908	PRAIRIE ROSE LAKE	375
6	1906	LOST ISLAND LAKE	324
7	1909	RATHBUN RESERVOIR	319
8	1911	ROCK CREEK LAKE	314
9	1902	BIG CREEK RESERVOIR	296
10	1907	LAKE MACBRIDE	263
11	1914	VIKING LAKE	250
12	1905	LAKE DARLING	235
13	1910	RED ROCK LAKE	167
14	1903	BLACK HAWK LAKE	110
15	1912	SILVER LAKE	107

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/12/23

190401
43 07 30.0 093 24 00.0
CLEAR LAKE
19033 IOWA

11EPALES
4

2111202
0012 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/18	12 30	0000	8.9		55	33	8.30	147	0.200	1.300	0.260	0.031
	12 30	0005	8.8	11.4		117	8.30	148	0.190	1.200	0.240	0.006
74/07/03	13 05	0000	23.6	8.2	30	396	8.60					
	13 05	0005	23.6	7.0		398	8.60					
	13 05	0010	23.6	6.4		398	8.70					
74/09/23	14 55	0000	14.9	9.4	37	272	8.43	164	0.040	1.100	0.030	0.010
	14 55	0005	14.9	9.2		277	8.43	164	0.040	1.100	0.020	0.008
	14 55	0008	14.9	9.5		272	8.44	168	0.040	1.000	0.030	0.011

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/18	12 30	0000	0.034	12.6	
	12 30	0005	0.048		
74/07/03	13 05	0000		6.1	
74/09/23	14 55	0000	0.064	15.1	
	14 55	0001			50.0
	14 55	0005	0.097		
	14 55	0007			1.0
	14 55	0008	0.078		

STORET RETRIEVAL DATE 75/12/23

190402
43 07 30.0 093 25 50.0
CLEAR LAKE
19033 IOWA

11EPALES 2111202
4 0014 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/18	12 50	0000	9.0		55	24	8.30	147	0.200	1.300	0.260	0.011
	12 50	0005	9.0	11.8		114	8.30	147	0.190	1.100	0.290	0.009
	12 50	0010	9.0	10.4		184	8.35	148	0.180	1.200	0.290	0.009
74/07/03	13 30	0000	23.5	7.2	34	396	8.70					
	13 30	0006	23.5	7.4		400	8.60					
74/09/23	14 30	0000	14.6	9.0	36	270	8.34	164	0.040	1.300	0.020	0.007
	14 30	0005	14.6	9.2		270	8.41	165	0.040	1.000	0.020	0.011
	14 30	0009	14.6	9.0		286	8.41	163	0.040	1.300	0.020	0.011

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/18	12 50	0000	0.026	12.4	
	12 50	0005	0.025		
	12 50	0010	0.024		
74/07/03	13 30	0000		10.3	
74/09/23	14 30	0000	0.059	17.5	
	14 30	0001			50.0
	14 30	0005	0.081		
	14 30	0006			1.0
	14 30	0009	0.072		

STORET RETRIEVAL DATE 75/12/23

190403
43 07 20.0 093 28 00.0
CLEAR LAKE
19033 IOWA

11EPALES 2111202
4 0005 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/18	13 10	0000	11.4			47	8.70	140	0.080	1.200	1.000	0.017
74/07/03	11 15	0000	24.2J	6.4	18	394	8.60					
74/09/23	14 05	0000	13.5	9.8	14	251	8.53	155	0.050	1.500	0.020	0.009

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/18	13 10	0000	0.057	29.4	
74/07/03	11 15	0000		31.1	
74/09/23	14 05	0000	0.095	22.1	
	14 05	0001			50.0
	14 05	0004			1.0

J VALUE KNOWN TO BE IN ERROR